

BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
Department of Zoology
Syllabus of M.Sc. Zoology as per UGC Guidelines on CBCS
Course Structure

Semester – I					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	ZL-101	Biosystematics and Taxonomy	Core Course	3+1+0	04
2.	ZL-102	Comparative Anatomy of Vertebrates	Core Course	3+1+0	04
3.	ZL-103	Sericulture-I(General sericulture, Mulberry Pathology and Silkworm Rearing)	Core Course	3+1+0	04
4.	ZL-104	Sericulture-II(Silkworm Pathology, Grainage Management & Post Cocoon Technology)	Core Course	3+1+0	04
5.	ZL-105	Laboratory Course	Core Course	0+0+4	04
Discipline Specific Elective (DSE)					
1.	ZL(OE)-01	Population Ecology	Elective Course	3+1+0	04
Semester – II					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	ZL-201	Comparative Animal Physiology	Core Course	3+1+0	04
2.	ZL-202	Animal Behaviour	Core Course	3+1+0	04
3.	ZL-203	General Principles in Parasitology	Core Course	3+1+0	04
4.	ZL-204	Human Parasitology	Core Course	3+1+0	04
5.	ZL-205	Laboratory Course	Core Course	0+0+4	04
Discipline Specific Elective (DSE)					
1.	ZL(OE)-02	Economic Zoology	Elective Course	3+1+0	04
Semester – III					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	ZL-301	Molecular Cell Biology	Core Course	3+1+0	04
2.	ZL-302	Wildlife and Conservation Biology	Core Course	3+1+0	04
3.	ZL-303	Aquaculture and Fisheries - I	Core Course	3+1+0	04
4.	ZL-304	Aquaculture and Fisheries - II	Core Course	3+1+0	04
5.	ZL-305	Laboratory Course	Core Course	0+0+4	04
Any one from following					
1.	ZL-306	Aquarium Management	Elective Course	3+1+0	04
2.	ZL-307	Fish Processing Technology	Elective Course	3+1+0	04
Semester – IV					
Sl. No.	Paper Code	Paper Title	Type	L+T+P	Total Credits
1.	ZL-401	Dissertation and Viva-voce	Core Course	2+2+12	16
2.	ZL-402	Study Tour /Field Attachment and Viva-voce	Core Course	-	08

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Scheme of Examination

Semester – I					
Course Code	Course Title	Max Marks		Total Max	
		End Sem	Sessional	Marks	Credit
ZL-101	Biosystematics and Taxonomy	70	30	100	4
ZL-102	Comparative Anatomy of Vertebrates	70	30	100	4
ZL-103	Sericulture-I (General sericulture, Mulberry Pathology and Silkworm Rearing)	70	30	100	4
ZL-104	Sericulture-II (Silkworm Pathology, Grainage Management & Post Cocoon Technology)	70	30	100	4
ZL-105	Laboratory Course	70	30	100	4
DSE					
ZL(OE)-01	Population Ecology	70	30	100	4
Semester – II					
Course Code	Course Title	Max Marks		Total Max	
		End Sem	Sessional	Marks	Credit
ZL-201	Comparative Animal Physiology	70	30	100	4
ZL-202	Animal Behaviour	70	30	100	4
ZL-203	General Principles in Parasitology	70	30	100	4
ZL-204	Human Parasitology	70	30	100	4
ZL-205	Laboratory Course	70	30	100	4
DSE					
ZL(OE)-02	Economic Zoology	70	30	100	4
Semester – III					
Course Code	Course Title	Max Marks		Total Max	
		End Sem	Sessional	Marks	Credit
ZL-301	Molecular Cell Biology	70	30	100	4
ZL-302	Wildlife and Conservation Biology	70	30	100	4
ZL-303	Aquaculture and Fisheries - I	70	30	100	4
ZL-304	Aquaculture and Fisheries - II	70	30	100	4
ZL-305	Laboratory Course	70	30	100	4
Any one from following					
ZL-306	Aquarium Management	70	30	100	4
ZL-307	Fish Processing Technology	70	30	100	4
Semester – IV					
Course Code	Course Title	Max Marks		Total Max	
		End Sem	Sessional	Marks	Credit
ZL-401	Dissertation and Viva-voce	280	120	400	16
ZL-402	Study Tour /Field Attachment and Viva-voce	140	60	200	8

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Department of Zoology

Syllabus of M. Sc. Zoology as per UGC Guidelines on CBCS

The syllabus for M. Sc. Zoology based on semester with credit based pattern comprises of four semesters. The examination shall be of 04 core theory papers, each with 4 credits (4x4=16 credits), 1 elective paper of 4 credits each (1x4=4 credits), 1 laboratory course of 4 credits (1x4=4 credits). The fourth semester consists of 2 core papers for 16 and 8 credits. Thus, each semester offers 24 credits (4x24=96 credits). Each 4 credit theory paper is equivalent to 100 marks and the laboratory course consists of four modules (i.e. one module from each core paper). The Examination in each theory paper and laboratory course shall be of three hours duration.

Eligibility: Graduate degree with 50% marks (45% SC/ST/PH/OBC) in Zoology or any other examination considered to be equivalent will be eligible for admission to M.Sc. Course in Zoology.

Semester –I

Core Courses

ZL-101: Biosystematics and Taxonomy

Unit I

- Definition and basic concepts of biosystematics taxonomy and classification.
- History and theories of biological Classification.
- Trends in biosystematics: Chemotaxonomy, cytotaxonomy and molecular taxonomy
- Dimensions of speciation. Species concepts: Typological, Nominalistic and Biological species concepts. Subspecies and other infra-specific categories.

Unit II

- Taxonomic Characters and different kinds.
- Origin of reproductive isolation, biological mechanism of genetic incompatibility.
- Taxonomic procedures: Taxonomic collections, preservation, curation, process of identification.

Unit III

- Taxonomic keys, different types of keys, their merits and demerits.
- International code of Zoological Nomenclature (ICZN): Operative principles, interpretation and application of important rules: Formation of Scientific names of various Taxa.
- Synonyms, homonyms and tautonymy.

Unit IV

- Evaluation of biodiversity indices.
- Evaluation of Shannon Weiner Index.
- Evaluation of Dominance Index.
- Similarity and Dissimilarity Index.

Suggested Reading Material (All latest editions)

1. M.Kato. The Biology of Biodiversity, Springer.

2. J.C. Avise. Molecular Markers, Natural History and Evolution, Chapman & Hall, New York.
3. E.O. Wilson. Biodiversity, Academic Press, Washington.
4. G.G. Simpson. Principle of animal taxonomy, Oxford IBH Publishing Company.
5. E. Mayer. Elements of Taxonomy.
6. E.O. Wilson. The Diversity of Life (The College Edition), W.W. Northem& Co.
7. B.K. Tikadar. Threatened Animals of India, ZSI Publication, Calcutta.

ZL-102: Comparative Anatomy of Vertebrates

Unit 1: Chordates, Proto chordates and Vertebrate Integument

- Characters and Classification of proto-chordata, significance of protochordates in the evolution.
- Origin of chordates and classification
- Vertebrate integument: development, structure and function of skin in vertebrates.
- Derivatives of Integument: development, structure and function of glands, scales, horns, claws, Hoofs, feathers & hair.

Unit 2: Skeletal and Digestive system

- Comparative account of jaw suspension
- Comparative account of vertebral column
- Comparative account of girdles and limbs.
- Comparative account of digestive system, anatomy of gut in relation of to feeding habits- Herbivores, carnivores and omnivores.

Unit 3: Circulation and respiration

- Evolution of heart
- Evolution of aortic arches and portal system
- Respiratory organs in fishes and amphibians
- Air sacs in birds, respiration in mammals

Unit 4: Nervous and Urino-genital systems

- Comparative anatomy of brain in vertebrates (teleost, frog, lizard, fowl and rat)
- Nerves - cranial, peripheral and Autonomous nervous system
- Sense organs- simple receptors, organs of olfaction and taste, Lateral line system and Electric organs
- Evolution of urino-genital system in vertebrate series.

ZL-103: Sericulture –I (General sericulture and Silkworm Rearing)

Unit 1

- Origin and History of Sericulture.
- Silk Industry in India and World.
- Types of mulberry and non-mulberry silkworms.
- Food plants of Non Mulberry Silkworms.

Unit 2

- Origin, distribution and taxonomy of mulberry
- Soil and water management related to Mulberry fields.

- Mulberry plant Nutrient management: Kinds of manures and chemical fertilizers.
- Nursery management.
- Different types of Plantation Patterns in Mulberry.
- Pruning methods and importance for mulberry.
- Mulberry pathology: Diseases and pests of mulberry.
- Weeds in mulberry garden and their management.

Unit 3

- Life cycle of *Bombyxmori*.
- Morphological features of egg, larva, pupa and adult.
- Morphology and Anatomical features of Digestive, Circulatory, Respiratory and Excretory System of Larvae and Adult.
- Morphology and Anatomical Features of Nervous, Glandular, Muscular and Reproductive System of Larva and adult.

Unit 4

- Rearing Plan.
- Rearing and Environment.
- Disinfections and hygiene-principle of disinfection, types of disinfectants, disinfecting methods-preparation of solution-maintenance of hygienic conditions in the rearing house.
- Incubation technology and its requirements.
- Rearing technology for young and late age silkworms
- Leaf Storage and preservation technology for different scales of rearing.
- Cocoon harvest technology.

ZL-104- Sericulture-II

(Silkworm Pathology, Grainage Management & Post Cocoon Technology)

Unit 1

- Disease management, diagnosis of disease in larva, pupa and moth, moth examination, principle and method.
- Microsporidians, classification and biology of microsporidians infecting lepidopterans and silkworm, causal agent, symptoms, mode of transmission, pathogenicity, cross infectivity, alternate host, diagnosis&control method.
- Viral Diseases, in silkworm; Nuclear Polyhedrosis, Cytoplasmic Polyhedrosis, Infectious Flacherie and Densonucleosis, causal agent, symptoms, mode of infection, transmission, multiplication and pathogenicity. Diagnosis of viral diseases, Control.

Unit 2

- Bacterial Diseases, of silkworm, Bacterial diseases of digestive organs, Septicemia and Sototo disease, causal agent, symptoms, mode of infection and pathogenicity, diagnosis of disease, and their control.
- Fungal diseases of silkworm, types of muscardine and aspergillosis; causal agent, mode of infection, symptoms, multiplication and pathogenicity, diagnosis of disease, and their control.
- Silkworm Pests and their Management.

Unit 3

- Silkworm seed organisation, significance of seed organization; Basic seed multiplication centres P4, P3, P2 and P1
- Types of seed - industrial and reproductive seed, loose eggs, sheet eggs.
- Seed Production Process – disinfection methods, sorting, seed cocoon preservation, pupae sexing, emergence of moths, isolation, Pairing and depairing, egg laying, moth examination, surface disinfection, quality control.
- Acid Treatment – hot acid and cold acid, short term chilling and acid treatment, Long term chilling and acid treatment.
- Transportation of eggs, methods of transportation.

Unit 4

- Assessment of cocoon properties, and study of different type of defective cocoons.
- Different types of Cocoon Stifling, Cooking, and Brushing Methods.
- Reeling- definition of reeling, principle involved – direct system and indirect system of reeling & study of different type of Silk reeling machines.
- Silk Re-reeling, purpose, Structure of Re-Reeling Machine.

ZL-105 – Laboratory Course

Module – I

- Composition assessment of the taxonomic diversity/biodiversity in a habitat (e.g. grassland, arid land, wet land, etc.).
- Influence of climatic conditions on taxonomic diversity in a given habitat.
- Preparation of models showing the status of certain taxa or species in a particular habitat.

Module – II

- Study of museum specimens using already available specimens in the museum/ charts/ models/ photographs/ digital alternatives etc.
- Classification of vertebrates up to order and comments on the specimens representing all phyla/classes.
- Anatomical observations, demonstration and detailed explanation of the following with the help of ICT tools/ models/ charts/ photographs etc.
 - a) Brain and cranial nerves- Fish/ Rat.
 - b) Arterial and venous systems- Fish/Rat.
 - c) Urinogenital system- Fish/Rat.
 - d) Reproductive systems- Fish/Rat.
 - e) Internal ear in fish, Weberian ossicles in fish, accessory respiratory organs in fish.
- Study of Stained Permanent preparation of scales, ampullae of Lorenzini, otolith, striated muscles and cartilage of fish using animal wastes from local recognized fish markets or with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
- Study of slides of internal organs of vertebrates with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- Study of Axial and appendicular skeleton of fowl and rabbit using already available skeleton/ ICT tools/ models/ charts/ photographs etc.

Module – III

- Sericulture maps (a) World maps and Silk Road. (b) Sericulture map of India and Uttar Pradesh
- Study of different food plants of mulberry and non-mulberry by preparation of herbarium.
- Preparation of nursery bed.
- Pruning of mulberry plants.
- Soil analysis related to mulberry crop.
- Study of powdery mildew, leaf spot and leaf rust through sectioning, staining and temporary mounting.
- Collection, mounting/preservation of insect pests of mulberry (field work).
- Identification of mulberry pests. Study of nature of damage of the following pests: Leaf roller, Bihar hairy caterpillar, scale insect, mealy bug, thrips, beetles, jassids and grasshoppers.
- Study of different weeds of mulberry garden, their management and herbarium preparation.
- Study of different garden equipments.
- Dissection of the larvae of *Bombyxmori*: Digestive system, Nervous system, excretory system, Respiratory system and Silk Gland. Permanent preparation and study of different parts of larvae: Mouth parts, spiracle and trachea.
- Preparation of different disinfectants and their application.
- Study of different rearing equipments.
- Incubation of silkworm eggs, blackboxing and hatching.
- Brushing, cleaning and chopping of leaves.
- Individual rearing
- Cocoon Harvesting.

Module – IV

- Handling of grainage cocoons.
- Preparation of different types of silkworm eggs.
- Cocoon Assessment.
- Cocoon cooking by open pan and three pans methods.
- Reeling Techniques viz. Improved Charkha, Multi ends reeling machine.
- Re-reeling.

Discipline Specific Elective (DSE)

ZL(OE)-01: Population Ecology

Unit 1

- Population Growth: Population growth and their characteristics, exponential growth, Verhulst – Pearl logistic growth model.
- Stochastic models of population growth, stable age distribution, Life table.

Unit 2

- Competition and Niche Theory: intraspecific and interspecific competition, history of niche concepts, theory of limiting similarity
- Ecological interdependence and interaction (mutualism, commensalism, amensalism, neutralism, symbiosis, parasitism.)
- Evolution of mutualism, Plant – pollinator and animal – animal interactions basic models

Unit 3

- Population Regulation: Extrinsic and Intrinsic Mechanisms
- Hardy-Weinberg Equilibrium (their application, equation, factors affecting the Hardy-Weinberg law)
- Lotka-Volterra Model (their equation, application, measuring parameter of Lotka-Volterra model)

Unit 4

- Life history strategies: Evolution of life history traits, longevity and theories of ageing,
- Geological time scale.
- Parental investment and offspring, reproductive strategies – ecology and evolution of sex and mating systems, optimal body size, r and k selection

Suggested Reading Material

- Begon, M., J.L. Harper and C.R. Townsend. Ecology, Individuals, Populations and Communities. Blackwell Science, Oxford, UK.
- Cherrett, J.M. Ecological concepts. Blackwell Sci. Publ. Oxford, UK.
- Elseth, B.D. and K.M. Baumgartner. Population biology. Van Nostrand Co., New York.
- Jorgensen, S.E. Fundamentals of ecological modeling. Elsevier, New York.
- Krebs, C.J. Ecology. Harper & Row, New York.
- Krebs, C.J. Ecological methodology. Harper & Row, New York.
- Ludwig, J.A. and J.F. Reynolds, 1988. Statistical ecology. John Wiley & Sons, New York.
- Pianka, E.R. Evolutionary ecology. Harper & Row, New York.
- Ricklefs, R.E. and G. Miller. Ecology, W.H. Freeman & Co., New York.
- Roughgarden, J., Ecological methods. Southwood, T.R.E.
- Swartzman, G.L. and S.P. Kaluzny. Ecological simulation primer. MacMillan, New York.
- Roff, O.A. The evolution of life histories. Theory and Analysis. Chapman & Hall, London, UK.

Semester -II

Core Courses

ZL-201: Comparative Animal Physiology

Unit 1

- Principles of Animal Physiology-Idea of mechanistic and Evolutionary physiology. Homeostasis in different forms.
- Size and Scale of organisms-Size and Surface area to volume ratio. Metabolic scope (Scaling relationship) between BMR and Body mass. Metabolic rates as a function of body mass in mammals and arthropods. Metabolic rate as a function of animal locomotor speed in locust and migratory butterfly, rainbow trouts, and speedy cheetah.

Unit 2

- Thermal Physiology- Heat Transfer between animal and environment. Poikilothermy and Homeothermy. Physiological adjustments in extreme environmental conditions.
- Sensory Physiology-Lateral Inhibition and enhanced edge effect in invertebrates under different illumination. Receptor system and sensory perception in phytophagous insects. Phototransduction in compound and vertebrate eye.

Unit 3

- Physiology of Excretion- Physiology of ultrafiltration, Reabsorption, tubular secretion. Counter current theory of urine concentration, Regulation of urine formation. Method of Urine formation, Nitrogenous wastes. Renal regulation of acid-base balance.
- Physiology of blood and body fluids -Comparative structure of cells in circulation of invertebrate and vertebrates. Composition of blood, Plasma and blood Corpuscles, in vertebrates, Functions. Haemopoiesis.

Unit 4

- Physiology of Respiration- Respiratory pigments in animals. Physiology of aerial and aquatic respiration in invertebrates and vertebrate examples. Respiratory adaptations in animals living in O₂ deficient environment.
- Physiology of behavior- Pheromones in colonial interactions, foraging and mating. Allelochemicals in plant-Insect interaction. Chemotaxis.

Suggested Reading Materials:

- Conn, Stumpi RK, Bruening and Doc: Outlines of Biochemistry (Wiley)
- Ganong: Review of Medical Physiology (Lange)
- Eckert, R: Animal Physiology (W.H. Freeman).

ZL-202: Animal Behaviour

Unit 1

- Behaviour: Definition - Innate behaviour, learning, reasoning, motivation, conflict and sexual behaviour.
- Migration and homing with special reference to birds.
- Communication in animals: Visual, olfactory, auditory and tactile.
- Camouflage and Mimicry – types of mimicry

Unit 2

- Ecological Aspects of Behaviour: Habitat selection, food selection and optimal foraging theory, anti-predator defense mechanisms, aggression, territoriality and dispersal.
- Social Behaviour: Aggregations – Schooling in fishes, flocking in birds, herding in mammals; group selection, kin selection, altruism, inclusive fitness, and social organization in insects and primates.

Unit 3

- Reproductive Behaviour: Evolution of sex, reproductive strategies, mating systems, courtship, sperm competition, sexual selection and parental care.
- Hormones and behaviour, pheromones and behaviour.

Unit 4

- Biological rhythms: Circadian, circannual, tidal/lunar, ultradian, infradian rhythms, synchronization of biological rhythms, phase shift.
- Photoperiodism with reference to birds and mammals - human circadian rhythms.

Suggested Reading Materials:

- Drickamer & Vessey: Animal Behaviour, Concepts, Processes and Methods (Wadsworth)
- Grier: Biology of Animal Behaviour (Mosby College)
- Immelmann: Introduction to Ethology (Plenum Press)
- Lorenz: The Foundation of Ethology (Springer-Verlag)
- Manning: An Introduction to Animal Behaviour (Addison - Wesley)
- McFarland: Animal Behaviour, Psychology, Ethology and Evolution (Pitman)
- Price & Stoker: Animal behaviour in laboratory and field (Freeman)
- Wood-Gush: Elements of Ethology (Chapman and Hall)

ZL-203: Parasitology-I

Unit 1: Introduction to Parasitology

- Inter-specific biological relationships- phoresis, symbiosis, Commensalisms and parasitism.
- Parasitism- Definition & concept, Origin and evolution of parasites, Types of Parasites and Hosts, interrelationship between Host and Parasites, responses and hosts to parasitic infection
- Mode of transmission of parasite, Host specificity and parasitic adaptation, Zoonoses, Bioinvasion.
- Factors influencing Parasitism; Influence of season, host age and other phonological factor on parasitic population (prevalence, intensity etc).

Unit 2: General organization and Classification of Parasites

- General organization and classification of Protozoa upto order level
- General organization and Classification of Platyhelminthes up to order level. Cestodes (Cestodarians and Eucestodes), Trematodes (Monogenea, Aspidobothria and Digenea)

- General organization and Classification of parasitic nematodes upto family level

Unit 3: Morphology and Anatomy of Helminth Parasites

- Ultrastructure of tegument, Holdfast organs with its adaptations in cestodes.
- Functional anatomy of Reproductive system in Trematodes (Digeneans) and Cestodes (Pseudophyllideans & Cyclophyllideans).
- Egg shell formation, factor influencing embryonation & hatching
- Larval forms, Intramolluscan stages and their effect on molluscan hosts, types of Cercaria, Different types of larvae in Cestodes.

Unit 4: Morphology and Anatomy of Nematode Parasites

- Body wall in nematodes, Ultra structure of Cuticle, Cuticular specializations, Chemical Composition.
- Digestive system, Feeding and Nutrition in nematodes.
- Excretory System, Nervous System and sense organs.
- Reproductive system, egg, oviposition, Development and hatching of eggs, Moulting and Larval forms in nematodes.

ZL-204: Parasitology- II

Unit 1

Morphology, host range, location, life cycle, pathogenicity, treatment and prophylaxis of the following:

- Intestinal protozoans (*Entamoeba*, *Giardia*);
- Haemoprotozoans (*Trypanosoma*, *Plasmodium*, *Leishmania*).
- Other Tissue protozoans (*Toxoplasma*)

Unit 2

Morphology, host range, location, life cycle, pathogenicity, treatment and prophylaxis of following:

- Liver flukes (*Clonorchis sinensis*, *Fasciola hepatica*),
- Lung fluke (*Paragonimus westermani*),
- Blood fluke (*Schistosoma haematobium*);

Unit 3

Morphology, host range, location, life cycle, pathogenicity, treatment and prophylaxis of following type:

- Pork and beef tapeworm (*Taenia solium*, *T. saginata*)
- Dwarf tapeworm (*Hymenolepis nana*).
- Fish tapeworm (*Diphyllobothrium latum*)

Unit 4

Morphology, host range, location, life cycle, pathogenicity, treatment and prophylaxis of following:

- Intestinal nematodes (*Ascaris*, *Ancylostoma*, *Enterobius*),
- Blood nematodes (*Schistosoma sp.*, *Wuchereria bancrofti*)
- Tissue nematodes (*Trichinella spiralis*, , and *Dracanculus medinansis*).

Suggested Reading Materials:

- An introduction to Parasitology- Chandler and Read
- Parasitology - K. D. Chatterjee
- General Parasitology - Thomas C. Cheng
- Clinical Parasitology- Faust, Russel and Jung
- Medical Parasitology- Markell, Voge and John, 8thed. W.B. Saunders Co.
- Intracellular Parasitic Protozoa- Aikawa and Sterling
- Parasitic Protozoa- Baker
- The Physiology of Cestodes. - J.D Smyth
- Human helminthology Manual for Clinical, Sanitarians Medical Zoologists – Faust, Emerest Carroll.
- Systema Helminthum- S. Yamaguti, Inter- Science Publishers, London.
- An introduction to Nematodology – Chitwood
- Structure of Nematode - Allen bird

ZL-205: Laboratory Course

Module – I

- Haemoglobin estimation
- Blood cell count - haemocytometer
- Blood coagulation experiments
- Qualitative tests for sugars, proteins, lipids

Module – II

- Sleep - wake rhythm of human.
- Activity - rest budget of ungulates.
- Population estimation: Diversity, abundance, density, species richness and composition of birds.
- Habituation in earthworms.
- Study of individual patterns of behaviour, Study of social patterns of behaviour
- Interspecific association - cattle and egrets
- Flocking behaviour in pigeons.
- Film shows on animal behaviour.

Module – III

- Identification, classification and description of protozoan, helminth and nematode parasites through permanent slides / photomicrographs
- Study and identification of trophozoites, cysts of protozoan parasites; eggs of cestodes, trematodes, nematodes found in stool through permanent slides / photomicrographs / ICT tools / models / charts etc,
- Study of larva and molluscan stages of helminthes through permanent slides / photomicrographs
- Examination of faecal samples for eggs cysts and larvae of parasites.
- Collection and examination of molluscan hosts for larvae of trematodes
- Study of various animal associations through suitable examples

Module – IV

- Collection of trematodes, cestodes parasites from various hosts

- Preservation, staining, preparation of permanent slides and identification of collected trematode & cestode parasites.
- Study of different protozoan, trematodes, cestodes and nematodes from permanent slides.
- Microscopical Examination of blood smears for *Plasmodium stages*, *Leishmania amastigotes*, and microfilariae
- Collection from various hosts, preservation, mounting and identification of collected Nematodes

Submission: *At least five permanent slides to be submitted at the time of practical examination*

ZL(OE)-02: Economic Zoology

Unit 1: Apiculture

History & Classification, Biology of Honey Bees, Social Organization of Bee Colony(Queen, Drone, Worker).Economic Importance, Scope in Apiculture, Diseases & its control, Rearing of Bees, Bee Keeping Equipment. Bee Economy & Entrepreneurship in Apiculture.

Unit 2: Aquaculture

Introduction to fresh water aquaculture, aquaculture systems, Integrated farming Systems; Paddy cum fish culture, poultry cum fish culture, poultry-piggery cum fish culture, Waste water fed aquaculture. Physico-chemical properties of soil and water, Productivity & nutrient quality & quantity of soil and water, Soil and water quality monitoring and management.

Unit 3: Sericulture

Introduction to Sericulture, Types of mulberry and non-mulberry silkworms, Food plants of Silkworms. Different methods of Rearing, Diseases of silkworm and the ir control, Reeling methods. Economic income of Silk Industry.

Unit 4: Vermicomposting

Earthworms, Ecological role and economic importance of earthworms.Vermiculture – definition, scope and importance; Environmental requirements; Culture methods, Vermicomposting – applications, Future perspectives, Potentials and constraints for vermiculture in India.

Suggested Reading Materials:

- Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
- Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ.
- Edwards CA, Hendrix P and Arancon N (2014) Biology and Ecology of Earthworms, Springer Publishers.
- Edwards CA, Arancon NQ and Sherman RL (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management, CRC Press, USA.
- Ismail SA (2005) The Earthworm Book. Edition, Other India Press, Apusa, Goa, India.

Semester -III

Core Courses

ZL-301: Molecular Cell Biology

Unit 1

Nuclear Compartment:

- Nucleus – EM Structure.
- Nuclear envelope – structure & function.
- Chromosomes – Packaging of genome, chromosome structure, genetic maps, nucleolus.
- Information networks – Internet, HTTP, HTML URLs, E M B net, NCBI, Japan net. Protein information – databases.
- Genome information – databases also).

Unit 2

Secretory Pathway:

- ER-structure (SER, RER), transport.
- Ribosomes, polysomes, free ribosomes, membrane associated ribosomes & secretory pathway.
- Vesicles involved in intracellular transport.
- Assembly of cell organelles.

Unit 3

Cellular respiration & degradation:

- Mitochondria structure, assembly components.
- Peroxisomes – structure and functions.
- Endosomes – late and early – structure, formation, assembly components.
- Lysosomes – structure & polymorphism.
- Proteosomes – types structures, assembly & functions.

Unit 4

Cell cycle division and signal transduction:

- Cell cycle – cyclins & cyclin dependent kinases & check points.
- Cytoskeleton & intracellular movement – microtubule, MTO C.
- Micro filaments & intermediate filaments.
- Meiosis.
- Mitosis – role of mitotic apparatus in cell division.
- Signal transduction. Receptor mediated.
- G proteins (adenylcyclase & ion channels phospholipase c).
- Non-receptor mediated.

Suggested Reading Materials:

- Molecular Cell Biology, J. Darnell, H. Lodish and D. Baltimore Scientific American Book, Inc., USA.
- Molecular Biology of the Cell, B. Alberts, D. Bray, J. Lewis, M. Raft, K. Roberts, and J.D. Watson. Garland Publishing Inc., New York.
- Molecular Biology of the Gene, J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner. The Benjamin/Cummings Pub. Co., Inc., California.
- Gene VI, Benjamin Lewin, Oxford University Press, U.K.

- Molecular Biology and Biotechnology. A comprehensive desk reference, R.A. Meyers (Ed.), VCH Publishers, Inc., New York.
- Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York.
- Introduction to Practical Molecular Biology, P.O. Dabre, John Wiley & Sons Ltd., New York.
- Molecular Biology LabFax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford.

ZL-302: Wildlife and Conservation Biology

Unit 1

- Wildlife in India- Wildlife wealth of India & threatened wildlife. Reasons for wildlife depletion in India. Wildlife conservation approaches and limitations. National and State mammals and birds of India.
- Wild life Habitat- Characteristic, Fauna and Adaptation with special reference to Tropical forest. Protected Area concept: National Parks, Sanctuaries and Biosphere Reserves, cores and Buffers, Nodes and corridors. Community Reserve and conservation Reserves

Unit 2

- Management of Wildlife- Red Data Book and Conservation status (endangered, vulnerable, rare, threatened and near threatened species)-definitions. Distribution, status. Habitat utilization pattern, threats to survival of Slender Loris, Musk deer, Great Indian Bustard, Olive Ridley turtle.
- Wild life Trade & legislation- Assessment, documentation, Prevention of trade. Policies and laws in Wild life management (national) and ethics.

Unit 3

- Biodiversity extinction and conservation approaches- Perspectives and Expressions. Identification and prioritization of Ecologically sensitive area (ESA). Coarse filter and fine filter approaches. Regional and National approaches for biodiversity conservation.
- Theory and analysis of Conservation of populations- Stochastic perturbations - Environmental, Demographic, spatial and genetic stochasticity. Population viability analysis-conceptual foundation, uses of PVA models. Management Decisions for small populations using PVA models. Minimum viable populations & recovery strategies for threatened species

Unit 4

- National and International efforts for conservation- Information on CITES, IUCN, CBD International agreements for conserving marine life. Convention on wetlands of International Importance (Ramsar convention). Important projects for the conservation of endangered species in India.
- Conservation of Natural Resources- Resources: Types and Degradations. Human impact on Terrestrial and Aquatic resources. Conservation of invertebrates with special reference to corals and butterflies. Overview of conservation of Forest & Grassland resources

Suggested Reading Materials:

- M.Kato. The Biology of Biodiversity, Springer.
- J.C. Avise. Molecular Markers, Natural History and Evolution, Chapman & Hall, New York.
- E.O. Wilson. Biodiversity, Academic Press, Washington.

- G.G. Simpson. Principle of animal taxonomy, Oxford IBH Publishing Company.
- E. Mayer. Elements of Taxonomy.
- E.O. Wilson. The Diversity of Life (The College Edition), W.W. Northem& Co.
- B.K. Tikadar. Threatened Animals of India, ZSI Publication, Calcutta.

ZL-303: Aquaculture and Fisheries I (General Aquaculture)

Unit 1

- Present Scenario and Problems: Trend in Global & Indian Aquaculture
- Environmental issues related to Aquaculture
- Strategies for Sustainability of Aquaculture
- Physico-chemical properties of soil and water, Productivity vs nutrient quality & quantity of soil and water, Soil and water quality monitoring and management

Unit 2

- Fish respiration and adaptive features: Gill structure and modifications, mechanisms of respiration, counter current mechanism, pneumatic ducts, air breathing organs
- Fish excretion: Comparative study of kidney structure in fishes, mechanism of excretion, osmoregulation physiology

Unit 3

- Fish nutrition: Role of nutrients, Nutritional biochemistry and Nutritional pathology
- Nutritional Physiology: Digestive system and its modification in fish
- Feed resources and Formulation

Unit 4

- Basics of Fish Health and Management, Defense system in Fishes, Techniques in health management
- Fish diseases: Parasitic and mycotic diseases, Infectious bacterial and viral diseases, Non Infectious diseases and their cure.

Suggested Reading Materials:

- W.S Hoar and D.J Randall - fish physiology.
- K.C Jayaram -The freshwater fishes of India.

ZL-304: Aquaculture & Fisheries- II (Seed Production, Hatchery Management & Aquaculture Techniques)

Unit 1

- Introduction; History, Constraints and current status of natural seed collection and hatchery seed production.
- Reproductive biology and Gamete Maturation & development mechanism.
- Environmental & endocrine control of reproduction.
- Induced Spawning and breeding mechanism, Brood stock management, seed collection
- Bait fish culture design & Management.

Unit 2

- Pond construction and management, Hatchery technology.
- Aquarium fish trade, Aquarium keeping, Value addition
- Fish farming: important cultivable finfish.

Unit 3

- Introduction to Coastal aquaculture.
- Different farming systems of coastal aquaculture.
- Important cultivable finfishes, Culture of marine molluscs & echinoderms.
- Pearl production and its value addition.

Unit 4

- Introduction to fresh water aquaculture, aquaculture systems, Fresh Water Prawn farming.
- Integrated farming Systems; Paddy cum fish culture, poultry cum fish culture, poultry-piggery cum fish culture.
- Waste water fed aquaculture.

Suggested Reading Material;

- W.S Hoar and D.J Randall - fish physiology.
- K.C Jayaram –The freshwater fishes of India.

ZL-305: Laboratory Course

Module – I

- Cell structure: prokaryotic and eukaryotic cell types with the operation of light microscope, phase contrast and polarising microscopes: Care and maintenance of the microscopes.
- Phase contrast microscopy-setting, measurements of refractive index, measurement of nuclear and cytoplasmic volume.
- Separation and isolation of cells by sedimentation velocity in unit gravity.
- Study of subcellular organelles: methods of disrupting cells.
- Isolation and identification of subcellular components of rat liver: Isolation of nuclei of rat liver hepatocytes.
- Isolation of mitochondria by differential centrifugation and identification of succinic dehydrogenase in the mitochondrial pellet.
- Isolation and estimation of DNA from rat liver hepatocytes.
- Agarose gel electrophoresis, staining and identification of nucleic acids.
- Chromosome segregation in mitosis and meiosis. Preparation of chromosome squashes from grasshopper / cockroach testes for the observation of the stages of meiosis.

Module – II

- Field work to understand basic ecological concepts.
- Survey of aquatic birds
- Scat analysis of predators

- Prey and predators relationships
- Laboratory experiments wherever possible.

Module – III

- Visit to conventional aquafarm to see the management of used water; Survey on environmental impact nearby aquaculture farms; Setting model for sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (Geographical Information System); Economic evaluation of Aquaculture practices.
- Equipment used in soil and water analysis; Soil sampling and determination of soil moisture and bulk density; pond filling, analyses of mud acidity and soil texture; Measurement of Temperature, pH, conductivity, salinity, transparency, turbidity and solids; Analysis of dissolved oxygen, alkalinity and hardness, phosphorus and nitrogen.
- Formulation and preparation of balanced fish feed; Feeding Trials; Estimation of protein and lipid quality; preparation of feeding table.
- General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Sampling and Preparation of media and culture of pathogenic bacteria; Techniques of bacterial classification; Histological techniques for disease diagnosis; molecular and immunological techniques; Biochemical tests; PCR; ELISA; Agglutination test; Challenge tests; Purification of Virus; Stress related study of fish and shellfish; Disease treatments.

Module – IV

- Study of gonadal development in carps and other cultivable finfishes; Identification of carp and catfish seed; Collection and identification of cultivable brackish water finfish seed; Packing and transportation of cultivable finfish seed; Induced breeding of fishes through various inducing agents; Evaluation of carp milt and egg; Design and operation of Chinese hatchery; Preparation of brood and larval feed for different cultivable finfish; Rearing of carp spawn and fry; Visit to different finfish hatcheries.
- Identification of common freshwater aquarium fishes and breeding trials of selected freshwater fishes; Identification of common brackish water and marine aquarium fishes; Aquarium fabrication, setting and maintenance; Preparation of powdered and pelleted feed for ornamental fishes; Visit to ornamental fish farms; Study of bacterial, viral, fungal diseases of ornamental fishes and their control; Prophylactic and quarantine measures; Nuclei implantation in pearl oyster; Identification ornamental aquatic plants.
- Identification of cultivable marine and brackishwater finfish and shellfish; Identification of cultivable seaweeds; Designing of different farming systems - cages, pens, rafts and racks; Visit to coastal aquafarms.
- Identification of commercially important cultivable fish and prawn species; Assessment of seed quality- stress test; Calculating carrying capacity of pond and stocking density; Check tray assessment and feed ration calculation; Sampling procedure and growth assessment; Lime and fertilizer requirement calculation; Modeling of different culture system.

Elective Courses
(Any one from following)

ZL-306: Aquarium Management

Unit 1

- Ornamental fishes: taxonomy, general and identifying character of Fresh water ornamental fish: Catfish, Cichlids, Cyprinids, Live-bearers,
- Marine water ornamental fish: Angelfish, Butterfly fish, Damsels, Eels, Flatfish, Gobies, Lionfish, Parrotfish, Pipefish, Rabbitfish, Rays, Scorpionfish, Seahorse, Sharks, Snappers, Tangs, Tilefish, Triggerfish.

Unit 2

- Construction of aquarium: types, filters, heater, calcium reactor, feed pump, bog-wood, driftwood, air-stone, live rock, substrate, fish-cam, fish feeder, lighting, other accessories.
- Coloration and Pigmentation: category; types; formation; dietary, neuronal, hormonal control. Uses and functions; morphology and physiology of color changes and its significance

Unit 3

- Culture with respect to Puntius and Clown fishes: Gonads (ovary, testis) morphology, histology and physiology, Endocrine and environmental control over gonadal cycle, Reproduction, fertilization, Different developmental stages.
- Feed formulation and feeding management.

Unit 4

- Diseases caused by ectoparasite and endoparasites: protozoan, helminth, bacterial, fungal, viral parasites, their symptoms
- Treatments and prophylaxis.

Suggested Reading Material

- 1. S. Felix, T.V. Anna Mercy, Saroj Kumar Swain (2013), Ornamental Aquaculture: Technology and Trade in India, Daya Publication House, New Delhi
- 2. Mac E. Hadley (2004), Endocrinology, 5th ed., Pearson Education (Singapore) Pt. Ltd.

ZL-307: Fish Processing Technology

Unit 1

- Fishing crafts; Principles of design and construction; Corrosion protection; Craft, materials - wood, marine plywood, fibreglass, reinforced plastic, aluminium, steel, ferro-cement; Bio-deterioration and preventive measures; Different types of fishing vessels in India; General arrangements of fishing vessels; Modern navigation equipment, navigation and fishing lights; Life saving devices

Unit 2

- Principles of fish preservation; Preservation of fish, sanitary requirements for maintenance of quality, processing ways of fish, Fish trade and its component,

Unit 3

- Fish craft as secondary earning of the fish trade person. Secondary utilization of fishery waste, as organic fertilizer, composition of fish waste in agriculture benefits, decorative piece as fish crafts, useful conversion of fish waste, different ways and their techniques.

Unit 4

- Economic importance of fish, it's by products and application, their processing ways, Fish market as a big trade, understanding of fish trade, employment types linked with fish trade, gender role in fish trade.

Suggested Reading Material

- W.S hoar and D.J Randall : fish physiology
- K.C. Jayaram: The freshwater fishes of India

Semester -IV

Core course

AS-401: Dissertation and Viva-voce

AS-402: Study Tour/Field Attachment and Viva-voce